AL/HR-TR-1995-0115

ARMSTRONG LABORATORY'S PARTICIPATION IN THE SYNTHETIC THEATER OF WAR-EUROPE EXERCISE: A SUMMARY REPORT

ARMSTRONG LABORATORY

Robert J. Clasen, Captain, USAF

HUMAN RESOURCES DIRECTORATE
AIRCREW TRAINING RESEARCH DIVISION
6001 South Power Road, Building 558
Mesa, Arizona 85206-0904

August 1995

Final Technical Report for Period April 1994 to November 1994

AIR FORCE MATERIEL COMMAND
BROOKS AIR FORCE BASE, TEXAS

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

Robert J. Clasen

ROBERT J. CLASEN, Capt, USAF
Project Scientist

Dee H. Andrews

DEE H. ANDREWS
Technical Director

Lynn A. Carroll

LYNN A. CARROLL, Colonel, USAF
Chief, Aircrew Training Research Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1995	Final Report - Apr 1994 to Nov 94

4. TITLE AND SUBTITLE

Armstrong Laboratory's Participation in the Synthetic Theater of War-Europe Exercise: A Summary Report

5. FUNDING NUMBERS

PE - 62205F
PR - 2743
TA - 25
WU - 20

6. AUTHOR(S)

Robert J. Clasen

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Armstrong Laboratory
Human Resources Directorate
Aircrew Training Research Division
6001 S. Power Road, Bldg 558
Mesa, AZ 85206-0904

8. PERFORMING ORGANIZATION REPORT NUMBER

AL/HR-TR-1995-0115

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

Armstrong Laboratory Technical Monitor: Capt Tina Derickson, (602) 988-6561

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Armstrong Laboratory's Aircrew Training Research Division (AL/HRA), located in Mesa, AZ, participated in the Synthetic Theater of War-Europe (STOW-E) exercise which occurred on 4-7 Nov 94. The goal of STOW-E was to enhance joint training capabilities by seamless integrating live, virtual, constructive simulations using Distributed Interactive Simulation (DIS) technology. These simulations (which were generated from 17 different sites throughout the United States, England, and Germany) communicated via the Defense Simulation Internet (DSI). AL/HRA provided two high-fidelity F-16 flight simulator cockpits and associated weapons. In addition, pilots, engineering expertise, and program management expertise were provided. The pilots flew joint simulated air interdiction missions, attacking ground targets. This report summarizes Armstrong Laboratory's participation in STOW-E, focusing on the following topics: the engineering effort that was required for the Laboratory to join STOW-E, how local exercise control and management were obtained, a description of the laboratory's operational scenarios, a listing of lessons learned, and, finally, a chronology of significant STOW-E events.

14. SUBJECT TERMS

Defense Simulation Internet, DIS; Distributed Interactive Simulation; DSI; Exercise; Flight simulation; Flight simulators; Flight training; Lessons learned; STOW-E; Synthetic Theater of War Europe;

15. NUMBER OF PAGES

15

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION ABSTRACT
Unclassified	Unclassified	Unclassified	UL

CONTENTS

FIGURES

PREFACE

This report summarizes the participation of Armstrong Laboratory's Aircrew Training Research Division (AL/HRA) in the Synthetic Theater of War - Europe (STOW-E) exercise. This effort was part of AL/HRA's Multiship Research and Development (MULTIRAD) program. The work was conducted under Work Unit Number 2743-25-20, Multiship Research and Development (MULTIRAD). Work unit monitor was Captain Tina Derickson. The principal investigator for Armstrong Laboratory was Captain Bob Clasen (AL/HRAD).

ARMSTRONG LABORATORY'S PARTICIPATION IN THE SYNTHETIC THEATER OF WAR-EUROPE EXERCISE: A SUMMARY REPORT

INTRODUCTION

Armstrong Laboratory's Aircrew Training Research Division (AL/HRA), located in Mesa, AZ, participated in the Synthetic Theater of War-Europe (STOW-E) exercise which occurred on 4-7 Nov 94. The goal of STOW-E was to enhance joint training capabilities by seamlessly integrating live, virtual, and constructive simulations using Distributed Interactive Simulation (DIS) technology. The use of DIS technology allowed for various simulations (e.g., aircraft, ships, missiles, tanks, and other entities) to merge into a realistic environment, permitting joint service interoperability for training elements at all levels. These simulations (which were generated from 17 different sites throughout the United States, England, and Germany) communicated via the Defense Simulation Internet (DSI).

AL/HRA provided two high-fidelity, virtual F-16 flight simulator cockpits and associated weapons. In addition, pilots, engineering expertise, and program management expertise were provided. The pilots flew joint air interdiction missions, attacking ground targets.

Armstrong Laboratory's participation in the STOW-E program began in Apr 94 with attendance at the Technical Working Group meeting. In Jul 94, AL/HRA became the first Air Force site to participate in a STOW-E SubSystem Integration Test (SSIT). The laboratory was an active member of all subsequent testing efforts and program reviews, helping other sites diagnose technical problems and pointing out potential programmatic problems.

The following paragraphs describe Armstrong Laboratory's participation in STOW-E. The description consists of sections which chronicle: the engineering effort that was required for the lab to join STOW-E; how local exercise control and management were maintained; a description of the laboratory's operational scenarios; a listing of lessons learned; and, finally, a chronology of significant STOW-E events.

ENGINEERING EFFORT

A significant engineering effort was required for AL/HRA to support STOW-E. Some of the more important engineering improvements are:

Connection to the Defense Simulation Internet (DSI)

The STOW-E exercise used the DSI for site connectivity. The DSI is a government-sponsored, general purpose, wide area network with enough performance to support distributed simulation. For STOW-E, the DSI was subdivided into two different networks based on security classification: unclassified and classified. During the four-day exercise, data from the unclassified network were placed on the classified net via a one-way security bridge. This allowed classified entities to see unclassified entities, but not vice versa. Armstrong Laboratory, like all Navy sites and most Air Force sites, participated on the classified network.

Because AL/HRA is not a DSI node, special arrangements had to be made to allow connection to the DSI. We used a "back door" connection to the Manned Flight Simulation Facility at Patuxent River NAS, MD, which is a DSI node. A T-1 communication line connected Armstrong Laboratory to Patuxent River, and thus to the DSI. Since the simulation data were classified, the data traveling over the T-1 line needed to be encrypted. This was accomplished by using KG-94 equipment (and its associated keying material) on both ends of the T-1 line. The T-1 line, Communications Security (COMSEC) keying material accounts, and security memorandum of agreement were previously established for another project.

Figure 1 shows a diagram of Armstrong's connectivity to the DSI.

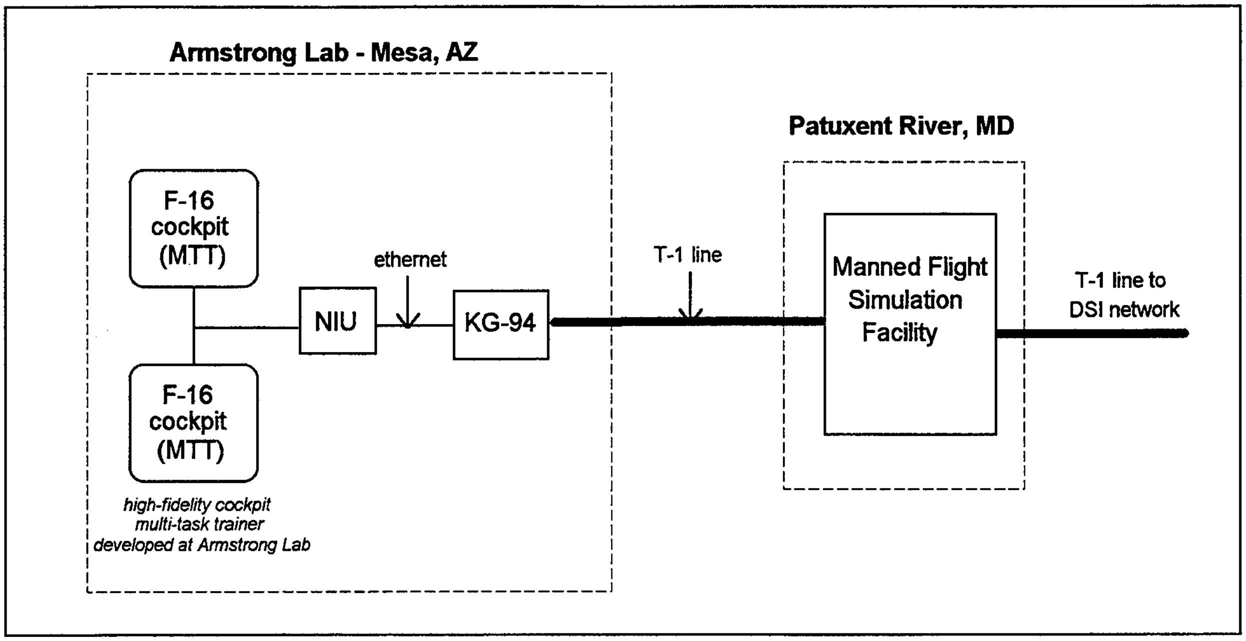

Figure 1.

Armstrong Laboratory's Connection to the DSI

Germany Database

Since the STOW-E battlefield was on German terrain, all STOW-E sites required a German database for their visual image generators. Most sites were provided with a German database by the Army Topographic Engineering Center. AL/HRA was not able to use that database due to system compatibility problems with its image generator. As a result, we were forced to generate a database for Germany using Defense Mapping Agency source data. In addition to generating terrain and culture data, we had to create some new entity models for ground vehicles that had never been needed before. Once the scenario was completed and targeting information was known, static target landmarks (e.g., power plants, road intersections, etc.) were placed on the database.

To prevent the unsightly appearance of floating ground vehicles as a result of database correlation differences, we used a previously developed Terrain Interface Unit (TIU). The TIU ignores the elevation data in the ground vehicle's Protocol Data Unit (PDU) and, instead, uses the elevation data from the visual database for that location.

This "clamps" the vehicle to the ground and, as a result, all vehicles are placed exactly where they should be on the out-the-window terrain.

Multiship Support Station

Armstrong Laboratory's Multiship Support Station (MSS) acts as a command console to provide local control of an exercise. The MSS gives a two-dimensional, god's-eye view of the simulated world, allowing the program director to monitor the activities of all the other sites on the network. To support STOW-E requirements, several enhancements were added to the MSS. The MSS was modified to support the large amount of entity traffic on the STOW-E classified network. During the four-day exercise, entity counts consistently exceeded 1,700. Prior to STOW-E, there was never a need for the MSS to display more than about 100 entities at one time, so some significant engineering changes were required to accommodate the heavy network traffic.

Another MSS modification made it easier for the program director to determine which other sites were currently on the network. With so many other sites connected to the network, it was difficult to quickly see which other sites were generating entities. A new display was added to the MSS that graphically showed which sites were currently active. In addition, by clicking on individual entity icons on the god's-eye display, the program director could determine which site was generating that particular entity. Though not all these features were fully implemented by the completion of STOW-E, new capabilities that were implemented greatly reduced the program director's workload.

Network Interface Unit

The Network Interface Unit (NIU) is the device which allows Armstrong Laboratory's F-16 cockpits to communicate with other entities by using DIS 2.0.3 protocols. The vast majority of STOW-E entities were ground vehicle entities. Most of these vehicles were outside of the operations area of the pilots flying Armstrong Laboratory's simulator cockpits. To reduce the NIU's processing load, the NIU was modified so that all ground targets outside a given radius of the F-16s were filtered out. The NIU then did not have to process ground entities that had no impact on the mission.

Communication System

The STOW-E voice communication system was based on the use of Defense Switched Network (DSN) conference calls. No voice PDUs were transmitted on the data network at all during STOW-E due to concerns about the limited amount of available bandwidth. As a result, we had to design a new phone-based communication system to accommodate STOW-E requirements.

Four new phone lines were brought into the Armstrong Laboratory TEMPEST facility: one for the scenario/exercise control network, one for the technical network, one for tactical communications with the Airborne Warning and Control System (AWACS) network, and one spare line. Figure 2 is a diagram of Armstrong's STOW-E communication system.

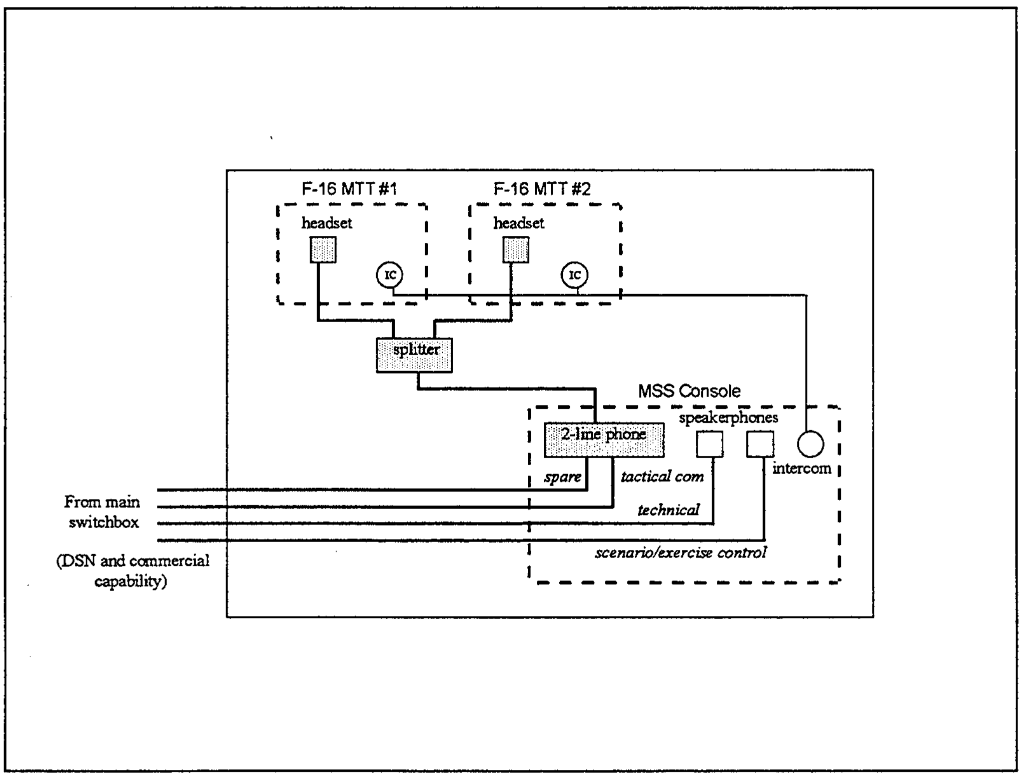

Figure 2.

Armstrong Laboratory's Communication System for STOW-E.

New telephone-compatible headsets were placed in the cockpits to allow the F-16 pilots to communicate with the AWACS controller via the tactical communication network. A low-fidelity intercom system was installed to allow the program director at the MSS console to communicate directly with the pilots in the cockpit without having to transmit over one of the voice communication networks. This allowed the program director to notify the pilots of the network status and other pertinent information without having to tie up one of the voice networks.

EXERCISE CONTROL AND MANAGEMENT

The second major area of effort for Armstrong Laboratory's participation in STOW-E was in exercise control and management. This section will describe the daily routine of the program director, the use of the MSS to monitor the exercise, and the use of network tools to monitor the DSI.

The daily routine of the Armstrong Laboratory STOW-E program director did not vary much from day to day. The first event of each day was powering up and keying the KG-94 encryption equipment, and then ensuring the T-1 link with Patuxent River NAS was operating. Once that was accomplished, the program director established connections to all applicable conference call communication networks. The program director would also make sure the cockpits, visuals, NIUs, and MSS were operational and ready. Then, in accordance with guidance from the exercise control network, the program director would follow and direct events according to the scenario script and would monitor scenario progress on the MSS. At the same time, he would use network analysis tools to monitor the status of other sites on the DSI net. All significant activities were recorded on a daily activity log.

The program director relied heavily on the MSS to provide an accurate depiction of what was happening on the network. The god's-eye view display gave an immediate status of the unfolding scenario. The MSS also had cockpit instrument repeaters and visual repeaters for both Armstrong Laboratory cockpits. The program director was able to get detailed information (position, speed, site of origin, etc.) on specific entities by

using the MSS. These features allowed the program director to more effectively control and manage AL/HRA's participation in STOW-E.

We also relied on network monitoring devices. These devices (dataloggers, real-time network monitors, etc.) allowed the program director to determine the DSI status and the status of individual sites. In addition, they allowed the detection of unusual or nonstandard PDU data on the network.

SCENARIOS

AL/HRA pilots flew two air interdiction missions on each of the four days of the STOW-E exercise for a total of eight missions. Each of those missions consisted of two pilots flying high-fidelity, virtual F-16C cockpits and attacking ground entities generated by the Theater Air Command and Control Simulation Facility (TACCSF) at Kirtland AFB, NM. The pilots used Mk-82 bombs, AIM-9 air-to-air missiles, and AIM-120 air-to-air missiles to accomplish their missions. All missions started from Spangdahlem AB, Germany, and the ground targets were located in Germany. The F-16 pilots were under AWACS control (again from TACCSF) for all missions. On some missions, the Armstrong Laboratory pilots were joined by escort aircraft. The escorts were generated from the following sites: TACCSF at Kirtland AFB NM (F-15Cs), Grafenwoehr, Germany (FalconStar F-16C), WISSARD Oceana, VA (F/A-18s), and Patuxent River NAS, MD (F/A-18s and F-14s). AL/HRA used rated fighter pilots, both of whom were assigned to the laboratory, to fly the STOW-E missions.

LESSONS LEARNED

Overall, the four-day STOW-E exercise went very well. However, that does not mean that things could not have been done better. Some of the more important lessons learned from STOW-E are listed below.

DSI Network

Currently, the DSI is still immature and it cannot be considered a reliable system. Even though DSI reliability was very high for the four-day exercise, it took a tremendous amount of resources to make this possible. During months of system testing, large

portions of system time were wasted due to problems related to the DSI. The bottom line is: the DSI still cannot be relied on.

System Testing

System testing was not as effective as it could have been. The test period was so compressed that it was impossible to fully analyze results of the previous test before preparing for the next test. By the end of the test period, test planning meetings were not even held at all. As a result, lessons were not learned from the mistakes of the previous test. It would have been better to have had fewer test events that were of higher quality rather than many low-quality tests.

Another problem with system testing was that, during testing, the classified network did not have the amount of traffic on it that it did during the exercise. During months of testing, there was nowhere near the amount of network traffic that there was during the STOW-E exercise. On one day of testing, there were about 800 entities on the network, but typically, there were only about 100-200 entities present throughout the test period. Then, during the four-day exercise, there were suddenly about 1,700 entities on the net. This caused a number of local problems that should have been discovered and fixed months before. The expected amount of traffic should have been on the network months prior to the actual exercise.

Baselining the System

The STOW-E system configuration should have been baselined earlier than it was. Some sites introduced simulation devices to the STOW-E network late in the exercise. This resulted in some frantic last-minute troubleshooting to correct the problems that inevitably result when you introduce something new to a system. Also, if the system had been baselined earlier, the amount of network traffic during the exercise could have been predicted better . As it turned out, there was a surge in network traffic during the four-day exercise that caused problems at some sites. These problems could have been easily avoided if the STOW-E system configuration had been stabilized, or “frozen,” earlier.

Security Classification of Network

As mentioned earlier, there were two different STOW-E networks: one classified and one unclassified. Having two networks resulted in a couple of problems. The first problem concerned interaction. Even though unclassified entities appeared on the classified network, the classified entities could not really interact with them. If an aircraft (classified) dropped a bomb on an unclassified tank, the tank would never see it and thus would not recognize that it had been killed. The aircraft would see the tank get hit, but the tank would never die. It is difficult to conduct effective training in that environment. Currently, for true interaction among all players, the network needs to be either completely classified or completely unclassified.

The second problem was a result of piping the unclassified data onto the classified network via a one-way security guard. This caused an excessive amount of traffic on the net (about 1,700 entities) without any benefit. The classified entities (Air Force and Navy) could not interact with the unclassified entities (Army) anyway, so there was no advantage to flooding the net with unclassified entities. Of the 1,700 entities, probably only about 200 were classified. Things would have gone smoother if only those 200 entities were on the classified net. For example, DSI nodes would not have needed application gateway filtering devices, and perhaps the DSI net would have been more reliable.

CONCLUSION

From a technical standpoint, the STOW-E exercise can be considered a success. However, it is important to remember the needs of the user when determining the success of an initiative. Air Force pilots need effective training not just technical accomplishments. Too many programs are driven by technology and not by the requirements of the user. From an Air Force perspective, STOW-E now needs to start focusing more on "what we need to do" rather than "what we can do."

CHRONOLOGY

The following is a chronological listing of significant STOW-E events in which AL/HRA participated:

19 - 20 Apr 94	Technical Working Group Meeting
17 - 18 May 94	Critical Design Review
29 Jun 94	SubSystem Integration Test (SSIT)#4 Planning Meeting
8 - 16 Jul 94	SSIT#4 (Functional Validation - 1)
20 - 21 Jul 94	SSIT#4 Review/SSIT#5 Planning Meeting
2 - 3 Aug 94	Air Force Meeting (at HQ USAF/XOM)
4 - 5 Aug 94	Program Review
8 - 12 Aug 94	SSIT#5
16 - 17 Aug 94	SSIT#5 Review/SSIT#6 Planning Meeting
23 Aug 94	SSIT#7 (FV-2) Planning Meeting
25 - 30 Aug 94	SSIT#6
9 - 17 Sep 94	SSIT#7 (Functional Validation - 2)
22 - 23 Sep 94	Program Review
3 - 7 Oct 94	SSIT#8
4 Oct 94	Demo for US Secretary of Defense (in Germany)
19 - 21 Oct 94	STOW-E System Testing
25 - 27 Oct 94	STOW-E System Testing
1 - 3 Nov 94	STOW-E System Testing / Rehearsal
4 - 7 Nov 94	STOW-E Exercise